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CONTROLS

Sensor Troubleshooting

Application Note

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CONTROLS

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ABOUT THIS GUIDE

This guide provides general information on electronic sensors used for monitoring and control purposes.

It is intended to help users evaluate sensor performance, accuracy, expected lifespan, and reliability so that they can select sensors that are the best fit for their control applications.

It is also intended as a general guide to detecting and diagnosing problems with sensors and sensor readings.

INTRODUCTION

Sensors tend to have the shortest reliable life span of all control system components. This is due to several factors, including the types of sensors selected, the conditions being monitored, and the sensor environment.

By nature, most sensors cannot be protected from their environment – they must be exposed to it to make proper measurements. For these reasons, routine maintenance, calibration, and replacement of sensors will be an ongoing cost associated with your control system. At Argus, we try to provide the best fit in sensor selection to provide a balance of reliability, longevity, accuracy, resolution, minimal maintenance, and price.

Recognizing and resolving potential problems with sensors can be time consuming, frustrating, and sometimes costly. This guide is intended to provide a logical, systematic approach for the early recognition and evaluation of sensor problems.

The information provided here is meant to apply to sensors in general. Each sensor type has a specific set of procedures for calibrating and evaluating its performance. These procedures are contained in the manufacturer's documentation supplied with your sensor or a sensor-specific document supplied by Argus.

In addition, the operator manuals for I/O programs contain information on setup and calibration values for specific sensor types and brands. However, prior to consulting these, there are a few considerations common to all sensors that should be recognized.

To properly evaluate a problem with any installed sensor you must do two things:

1. Accurately detect and diagnose the problem

2. Determine the cause.

Diagnosing Problems

It is important to make sure that you have a real problem, particularly for what appears to be a minor deviation. Sometimes a problem is obvious, such as an open circuit or a shorted wire producing a reading far outside of the normal or expected range. However, it can be very difficult to diagnose or to even detect a sensor problem if the deviation is quite small. **Determining that there really is a problem can be more difficult than finding the cause of a problem**. For example:

- It is normal for measured air temperatures in a controlled climate to deviate by a few degrees depending upon the location of the sensors, radiant effects, drafts, and vertical orientation. Therefore, identical sensors located in the same controlled space may produce different readings.

- Humidity levels are extremely dynamic and temperature dependant

- The accuracy of many carbon dioxide sensors may be no better than +/- 100 ppm

Therefore, determining the correct reading in a dynamic field environment can be a challenge. Many proportional sensors share the following properties:

- **Resolution**: The smallest detectable increment of measurement

- **Accuracy**: The closeness of a reading to the actual value of the quantity being measured. Usually expressed as +/- % of the full-scale reading. These published values are usually carefully defined under controlled circumstances and may not be fully achievable in real world situations.

- **Repeatability**: The ability to reproduce readings when the same measured value is applied consecutively under the same conditions.

- **Hysteresis:** The difference in output when the measured Value is first approached with increasing and then decreasing values.

- **Lag:** The time delay between the output of a signal and the response of the instrument to which the signal is sent.

These values are usually published and supplied with your sensor. It follows that any deviations that do not exceed the claimed resolution, accuracy, repeatability, or time constrained limits of the sensor, cannot be considered a sensor problem (if you require greater accuracy than the sensor can resolve, then you need a different sensor. See the notes below). If a sensor deviates by slightly more than these values, it can be all but impossible to detect and diagnose the problem. Usually such minor deviations can only be evaluated under controlled laboratory conditions.

What accuracy do you really need?

When selecting appropriate sensors, cost, durability, and reliability are also important considerations. In general, Argus selects sensors that offer a good compromise of these sometimes competing qualities by consideration of the real needs of the application. For example, it is not appropriate to use an expensive and fragile laboratory sensor that is accurate to 0.02^oC to measure pipe temperatures in a greenhouse. Therefore Argus supplies a durable, relatively inexpensive sensor that is accurate to 0.2^oC. Even then, these sensors are generally far more accurate than is needed for control purposes, since attempting to achieve impossibly fine control objectives will often result in undue wear on equipment systems without a compensating payback in energy savings or production.

How Sensors Fail

1. **Sudden Failures** - if a sensor has to fail, the best way for it to do so is catastrophically. It should fail so badly that it produces readings that "go off the scale" in one direction or the other. These types of failures are relatively easy for both the Argus System and the system operator to detect since the failed readings simply can't be true. You can set upper and lower alarm limit thresholds on each sensor program screen to notify you if the sensor readings ever reach these amounts.

2. **Protracted Failures** – sometimes a sensor will not fail instantly. It will begin to fail in one direction over time. By reviewing the daily recorded data for the sensor you can often spot such problems before a complete failure is picked up by the Argus system alarm threshold limits.

3. **Offset Deviations** – sometimes a sensor will seem stable but will apparently read several units above or below the expected value. This may happen suddenly or slowly over time. Again, data recording may help spot this type of problem. Although rare, it can be quite subtle since it appears to behave properly in response to changing conditions. This is usually caused by signal losses in very long wiring runs, faulty wiring, loose or corroded connections, or problems with calibration and setup.

4. **Frozen Readings** – occasionally a sensor may fail in a manner that produces an apparently viable reading which shows little or no response to changing conditions. This can often be confirmed by reviewing recorded data. If the sensor does not appear to respond to expected daily changes then there is likely a problem.

5. **Unstable Readings** – "flaky" sensors show erratic behavior over time. They may behave normally most of the time with sudden extreme swings in readings. Loose or shorted wires, and intermittent contamination are common causes.

The Problem with Reference Instruments

There's an old saying, "A man with two watches never knows what time it is".

For confirmation of a minor deviation problem, it would seem that the most obvious approach is to simply compare the suspect sensor to a reference instrument. To check a temperature sensor, you might want to use a reference thermometer. However, reference thermometers, regardless of how accurate, are often of limited use for comparison purposes if the deviations are small. This is because it is very difficult to accurately compare readings with other sensors under field conditions due to minor variations in the sampled source and problems with the sampling methods that can only be corrected for under controlled laboratory situations.

Reference instruments may be useful however, for diagnosing somewhat larger deviations, provided you make sure you are measuring the same conditions. For example, a reference thermometer should be placed as close to the suspect sensor as possible, and be allowed sufficient time to come to equilibrium. Even if you are confident of your testing methods, which device are you going to trust if there is a difference?

Using an identical sensor for reference is another approach that often proves helpful, provided the two sensors are sampling the exact same condition. However, if there is a discrepancy, how do you know which one is at fault? You may need to resort to yet more identical sensors for comparison, hoping that at least some will produce similar readings.

This is not to imply that reference instruments cannot be used successfully in the field. However, you must temper your expectations and try to remove all sources of sampling and testing error.

Determining the Cause of Sensor Failures

Once you have established that there is a problem with a sensor reading, you must then track down the source. Often, the problem is not with the sensor unit, but with the wiring or wiring connections, water damage, electrical inductance or impedance, or improper sensor assignment and calibration. Some general causes of sensor problems can include:

Cause:	Contributing factors:
Sensor failure	• Defects, contamination, water, mechanical, or electrical damage
Poor placement	• Poor contact between the sensor and the material of interest
Defective wiring	• Loose, damaged, or broken wires and connections
Improper setup	• Wrong sensor type assignment, compensation, or calibration settings in the Argus program software

Sensor symptoms:	Common causes:
Very small deviations from expected readings (just beyond the stated resolution, accuracy, or repeatability of the instrument):	• Differences this small are nearly impossible to diagnose or even accurately detect in the field.
Larger deviations:	• Sensor readings may be correct, expectations may be wrong. Check the specifications for the sensor. • Poor wiring connections, ground loops, improper wire gauge, very long wiring run lengths and high operating temperatures may all result in increased error • Partial short-circuit. Often caused by water or fertilizer solution contamination of wires or circuitry. Very small amounts of water can cause problems. Replace failed sensor or wire. Protect instrument panels from water damage
Very Large Deviations:	• Short or open circuit in the sensor or the wiring • Sensor failure
Fluctuating readings: usually small changes (a few degrees)	• Water damage to a wire or sensor • Improperly set AC power frequency selection • Ground loops in the input wiring (unlikely) • Input channel with more than 5 Volts of externally sourced power (this usually results in larger changes) • Poor sensor location: subject to external or non representative interference such as sun on a temperature sensor, shade on a light sensor, or an ambient CO_2 sensor mounted too near a vent or boiler exhaust.

Sensor Troubleshooting Sequence

(Follow these steps once you have diagnosed a problem)

These generalized steps apply for trouble shooting most sensors. For more specific instructions, refer to the data sheets and manuals for each sensor type.

1. **Check the Argus System Settings**

   - Before considering other causes of problems, **make sure that sensor compensation is properly set up and calibrated in the Argus software**. Make sure that an input channel is assigned to the sensor program and that the correct sensor is physically wired to this input channel. Settings should be similar to the factory defaults found in the on-line help for the particular type of sensor used.

   - Contact Argus if you need assistance. If all appears correct, proceed to step 2.

2. **Sensor Maintenance and Recalibration**

   - If the sensor is aspirated, ensure that the fan or aspirator pump is working properly and the air filter, if any, is clean. If the sensor requires maintenance or periodic cleaning and recalibration (i.e. pH, CO_2, Wet Bulb/Dry Bulb Sensors) make sure this is done first. If the problem remains, proceed to step 3.

3. **Checking the Wiring Run**

   - Check your connections first to make sure they appear solid, isolated, and free of corrosion. Make sure that there is no possibility of a short or open circuit at any of the wiring terminals and connections. If you note any problems, try making new connections (cut and strip new wire ends) at the sensor and input terminal ends of the wiring run. Reconnect the sensor to the wiring run and check the readings.

   - To check for a shorted or open circuit somewhere in the wiring run, try disconnecting the sensor from the wiring run and shorting the wires together. You should observe a large increase/decrease in the raw readings in the sensor program relative to when the circuit is open. Alternately, you can check this with a hand held meter by shorting the wires at one end and measuring the resistance between the wires at the other end. (Some meters also have a continuity test mode). When the wires are shorted, you should read very low resistance. When they are open, you should read very high resistance. If the wiring run appears OK then you likely need to repair or replace the sensor

Other Possible Problems

Rarely, the problem may be with the Argus hardware or a sensor module interface. Occasionally, external equipment may produce interference. Call Argus if you suspect a problem of this nature.

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